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# An Evaluation of Procedures to Increase Medical Device Compliance

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# AN EVALUATION OF PROCEDURES TO INCREASE MEDICAL DEVICE COMPLIANCE

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## Abstract

Behavioral interventions have been implemented to increase compliance with medical devices across patient populations and target devices. Intervention to increase medical device compliance (MDC) can involve a variety of components, including different reinforcement, graduated exposure, extinction, and punishment with varying degrees of acceptability and feasibility. In the current study, we compared the effects of noncontingent (NCR) versus synchronous reinforcement schedules on the duration of MDC and latency to device removal with KN95 face masks with 2 patients with Autism Spectrum Disorder. Following an initial baseline phase demonstrating that both participants engaged in compliance for less than 5 min, we used a multielement design to compare NCR and synchronous reinforcement conditions to increase compliance. We then evaluated the effect of the percentile schedule of reinforcement on shaping compliance and parametrically evaluated the *m* value parameter of the percentile schedule. For one participant, NCR was sufficient to increase compliance to 5 min. For the other, neither NCR nor synchronous reinforcement alone were sufficient to increase MDC. However, both participants' latency to medical device removal increased substantially under a percentile schedule of reinforcement with an *m* value of 5. One participant's responding maintained in the absence of reinforcement contingencies. These findings support the use of NCR as an initial treatment approach to increase MDC and the percentile schedule of reinforcement to increase the duration of MDC.



*Key words:* medical device compliance, noncontingent reinforcement, synchronous reinforcement, percentile schedule

# Introduction

Patient adherence to medical advice can reduce health care utilization and costs, increase the effectiveness of lower-cost health interventions, and improve the efficiency of healthcare systems overall. The World Health Organization estimates that approximately 50% of patients in developed countries do not adhere to treatment recommendations for chronic conditions (Sabaté, 2003). Behavioral interventions are recognized as key in increasing adherence to medical advice both at the individual and group or public level, especially with pediatric patients (Kahana et al., 2008; Sabaté, 2003; Normand et al., 2021). Behavioral interventions have been implemented to increase compliance with a variety of health-related interventions such as hemodialysis, medication use, and cystic fibrosis treatment in both typically developing pediatric patients and pediatric patients with developmental disabilities (Carton & Schweitzer, 1996; Hagopian & Thompson, 1999; Kahana et al., 2008).

Approximately 17% of children in the United States are diagnosed with a developmental disability and approximately 1-2% of children worldwide have an Autism Spectrum Disorder (ASD; Centers for Disease Control and Prevention). Children with ASD contact healthcare systems more often compared to their typically developing peers and are also more likely to have comorbid medical conditions (Cuvo, 2011). Therefore, it is of paramount importance for children with ASD to acquire the skills necessary to participate in medical interventions to improve their quality of life and long-term health outcomes. Behavioral interventions have been implemented with children with ASD to increase their compliance with a variety of health-related procedures such as oral assessment (Cuvo, 2010a), physical exams (Cuvo, 2010b), and procedures

involving needles (Shabani et al., 2006). In addition, behavioral interventions have also been implemented with children with ASD to increase compliance with the use of medical devices such as medical bracelets (Cook et al., 2015), prescription glasses (DeLeon et al., 2008; Wolf et al., 1964), prescription prosthetics (Richling et al., 2011), and face masks (Halbur et al., 2021; Lillie et al., 2021; McHugh et al., 2022; Sivaraman et al., 2021).

One of the earliest demonstrations of an effective behavioral intervention to increase medical device compliance (MDC) with a child with ASD was conducted by Wolf et al. (1964) with a one participant who was at risk of losing his vision entirely if noncompliance with prescription glasses persisted. The primary intervention component was shaping, differentially reinforcing successive approximations of the target response of compliance with wearing prescription glasses in the correct position (i.e., with the earpieces over the ears and lenses in line with the eyes). Increases in the duration of MDC for the participant progressed slowly until higher quality reinforcers were identified by the experimenters and delivered contingent on the current target approximation of glasses wearing. The introduction of the more potent reinforcers resulted in rapid acquisition of compliance with wearing glasses across settings and with thinner schedules of reinforcement. At the conclusion of the study, the participant wore his glasses for up to 12 hours per day both in the intervention context and in the home context.

Compliance as defined in Wolf et al.’s (1964) demonstration can be considered passive, meaning that the individual is not required to emit a specific response, only to tolerate potentially aversive stimuli for a period of time without engaging in escape-

maintained problem behavior or other behavior incompatible with compliance (Cook et al., 2015; Cuvo, 2010). For example, the participant in Wolf et al.'s (1964) treatment demonstration was only required to tolerate the presence of the eyeglasses in the correct position on his face without removing the glasses or engaging in throwing the glasses following removal. In contrast, during an oral exam, individuals are required to emit responses following instructions provided by the dental hygienist (e.g., "Open your mouth a little wider please!") to be considered compliant during the exam. Differentiating between whether passive or active compliance is the target response is an important factor to consider in designing and implementing an effective treatment because the behavioral mechanisms underlying active and passive compliance may differ. For example, increasing active compliance may require teaching a set of novel target responses (e.g., teaching the listener response of mouth opening in response to the vocal instruction "Open your mouth" during an oral exam, teaching the listener response of emitting a vocal stimulus when in response to the vocal instruction, "Say ahhh!" duration a physical exam), whereas passive compliance consists of tolerating potentially aversive stimulation for a set period of time without engaging in challenging behavior (e.g., sitting still while tolerating a blood pressure cuff expanding and deflating without attempting to remove the cuff or elope from the exam room, tolerating the presence of a medical ID bracelet secured on the wrist for an extended duration of time).

One common component in interventions to increase passive and active medical compliance is differential reinforcement. Differential reinforcement for any behavior other than the target operant of noncompliance with the medical procedure or device (DRO) as well as differential reinforcement of the specific target operant of compliance

with the medical procedure or device (DRA) have both been successful strategies in improving MDC across a variety of participants and target medical behaviors. Differential reinforcement strategies have been implemented to increase compliance with medical exams (Stuesser & Roscoe, 2020), wearing a heart rate monitor (Dufour & Lanovaz, 2020), wearing a medical bracelet (Cook et al., 2015), blood glucose monitoring (Shabani & Fisher, 2006), wearing a face mask (Halbur et al., 2021; Lillie et al., 2021), and respiratory treatment for cystic fibrosis (Hagopian & Thompson, 1999). Both the use of differential positive reinforcement (Dufour & Lanovaz, 2020; Halbur et al., 2021; Lillie et al., 2021; Shabani & Fisher, 2006; Stuesser & Roscoe, 2020) and the use of differential negative reinforcement in the form of a period of escape from medical compliance (Cook et al., 2015) have been implemented to increase medical compliance.

A notable treatment component omitted in these interventions, except for Cook et al.'s (2015) and Halbur et al.'s (2021) evaluations, is the concurrent implementation of extinction for medical noncompliance. Although differential reinforcement, particularly DRA, is often defined conceptually and procedurally as inclusive of an extinction component, this definition of DRA is restrictive for both conceptual and practical reasons (Vollmer et al., 2020). Rather, it is more accurate to define differential reinforcement in terms of the behavior analytic model of choice (McDowell, 1989). That is, in the arrangement of differential reinforcement to promote the target (appropriate) behavior versus an inappropriate behavior, reinforcement available contingent on the target behavior must be greater than the reinforcement available contingent on engaging in the inappropriate behavior according to some dimension (e.g., rate, delay, duration,

magnitude, or quality). In such an arrangement, responding is allocated to the target behavior more often even if reinforcement is still available for the problematic response. This conceptual approach to differential reinforcement does not necessarily exclude extinction as a potential component of DRA but allows the practitioner to select differential reinforcement as a treatment even when extinction cannot be implemented for an inappropriate behavior. Compliance with medical procedures or devices is one such case in which extinction may not be feasible and may even be dangerous to implement depending on the medical equipment involved or the strength and size of the individual receiving intervention (Lerman et al., 1999; Stuesser & Roscoe, 2020). Therefore, examining the effects of interventions involving differential reinforcement for medical compliance that do not involve extinction is of great importance.

In addition to differential reinforcement, noncontingent reinforcement (NCR) has also been demonstrated as an effective component in medical compliance interventions in the literature for some individuals, often without the concurrent implementation of extinction. Two recent evaluations of interventions to increase passive medical compliance with wearing prescription prosthetics (Richling et al., 2011) and wearing eyeglasses (DeLeon et al., 2008) involved NCR as the primary treatment component. NCR is defined as providing preferred stimuli on a fixed time (FT) schedule irrespective of the target behavior and has been demonstrated to effectively increase appropriate behavior and decrease challenging behavior (Tucker et al., 1998). Richling et al. (2011) evaluated the effects of an escape only condition, an escape plus NCR condition that included preferred items and attention, and an escape plus NCR condition that included only attention on wearing prescribed prosthetics (a hearing aid and orthotic supports)

with the two participants in a multiple baseline across-participants design. In the escape only condition, which served as baseline, 15 s of escape from wearing the device was provided before the device was put back on the participant by the experimenter. No consequences were programmed for device compliance or other forms of problem behavior in the escape only condition. In the escape plus NCR condition, noncontingent continuous access to preferred items, continuous music, and approximately 5 s of attention on an FT 15 s schedule were provided in addition to the contingencies from the escape only condition. Both participants' percentage of session in compliance reached 100% during the escape plus NCR phase. Longer durations than the usual session duration of 5 min were probed during this phase (15 and 30 min for one participant and 10 and 30 min for the other), and compliance was maintained across the longer durations. In the final phase of the evaluation, the experimenters conducted one session each in the training context and two untrained contexts for each participant and implemented only noncontingent attention. Both participants maintained high levels of compliance across contexts and across durations, which ranged from 30 min to 3 hours.

Although NCR plus escape was an effective standalone intervention in Richling et al.'s (2011) evaluation for both participants, additional aversive contingencies were necessary to increase compliance to a clinically significant degree in DeLeon et al.'s (2008) evaluation. DeLeon et al. evaluated NCR plus escape (i.e., escape extinction was not implemented contingent on device removal) as a treatment for MDC with four participants in a reversal design in four stages with all sessions lasting 10 min except in the final maintenance and generalization stages. In the first three stages, mock glasses (glasses with no prescription lenses) were used. In the fourth stage, glasses with the

prescription lenses were introduced. One participant only participated in the initial baseline and NCR comparison stage because he reached clinically significant levels of compliance with wearing his eyeglasses during the NCR intervention alone. The three other participants' compliance with wearing their eyeglasses did not increase sufficiently in response to NCR, so a treatment package with additional components, response-blocking and response cost, was implemented in the next stage. The three remaining participants' compliance increased to clinically significant levels with the treatment package. In the third stage, treatment package components were systematically removed to identify the components necessary to sustain compliance. The response-blocking component alone was sufficient to sustain compliance for one participant, but the other two participants required the reintroduction of NCR plus response cost which was then faded to only NCR. In the fourth stage, maintenance and generalization were assessed by introducing the participants' prescription glasses and conducting sessions in general purpose area rather than a treatment room. Once the prescription lenses were introduced, NCR alone was not sufficient for one of the two participants whose treatment had been faded to NCR only to sustain compliance, so the response cost component was reintroduced. During the final phase for this participant, only the response blocking component was necessary to sustain compliance. The results of this evaluation illustrate that NCR can be an effective standalone intervention for passive MDC for some individuals but that other individuals require additional treatment components.

It is not immediately clear from the results of the two evaluations involving NCR as a treatment for MDC why NCR as a standalone intervention was effective for both

participants in Richling et al.'s (2011) evaluation but was only effective for one of the four participants in DeLeon et al.'s (2008). It is possible that for the participants who responded to NCR, NCR abolished the reinforcing value of device removal (Laraway et al., 2003), which could have led to habituation to the aversive properties of the medical devices (McSweeney et al., 1996). The untrained emergence of compliance for extended durations and generalization across contexts for participants in both studies further indicates a possible role of habituation in the effectiveness of NCR-based interventions for MDC. Kelley et al. (1984) conceptualized the allocation of responding to preferred stimuli when noncontingent access is provided while experiencing aversive stimulation as essentially a "distraction technique," which are commonly implemented as a component of adult pain management interventions.

Compared to packaged interventions, NCR as a standalone intervention offers the practical benefit of being simpler to implement with integrity because no discrimination between responses on the part of the implementer is required when delivering treatment contingencies. Given that extinction and punishment procedures have been associated with various undesirable side effects, may not be safe, realistic, or socially acceptable depending on the physical size, age, or cultural preferences of the individuals and families receiving intervention, and are recommended against as an initial treatment approach in the BACB ethics code, additional positive reinforcement contingencies should be considered to supplement the effects of NCR if NCR alone does not produce the desired degree of behavior change (Behavior Analyst Certification Board, 2014; Lerman et al., 1999; Lerman & Vorndran, 2002). There is a growing body of evidence that suggests that positive reinforcement can effectively compete with

negative reinforcement, resulting in the reduction of escape-maintained challenging behavior without the use of aversive contingencies (e.g., escape extinction, time-out from positive reinforcement, response cost, response blocking) across a variety of contexts and target responses (Lalli et al., 1999; Slocum & Vollmer, 2015).

Slocum and Vollmer (2015) compared the effects of a positive reinforcement contingency and a negative reinforcement contingency on the reduction of participant-specific forms of problem behavior with five participants using a reversal design with a multielement treatment comparison embedded. Functional analyses indicated that all participants' problem behavior were at least partially or exclusively escape-maintained. Therefore, the baseline phase of the evaluation was identical to the demand condition in the functional analysis (e.g., an experimenter delivered an instruction and least-to-most prompting procedure and delivered escape from the demand contingent on problem behavior) except that an intertrial interval of 3 s was included between instructions to equate to the delivery time in the positive reinforcement condition of the evaluation. The positive reinforcement condition was identical to baseline (i.e., problem behavior continued to produce escape) except that a small piece of an edible item was provided contingent on compliance with the instruction. The negative reinforcement condition was also identical to baseline except that a 30 s break was delivered contingent on compliance with the instruction. For all five participants, positive reinforcement produced decreases in problem behavior and increases in compliance. However, negative reinforcement only produced these effects in two participants. Additionally, for the two participants for whom decreases in problem behavior and increases in compliance were observed in the negative reinforcement condition, the effects were greater in the

positive reinforcement condition. Slocum and Vollmer's preparation and results are an example of the promise of utilizing positive reinforcement contingencies to increase compliance and decrease problem behavior without the addition of aversive contingencies to treatment. It is possible an additional positive reinforcement contingency for MDC coupled with the NCR arrangement such as in DeLeon et al. (2008) and Richling et al.'s (2011) evaluations could prove to increase MDC for individuals who do not respond to NCR alone by competing with the negative reinforcement contingency of device removal.

One additional positive reinforcement treatment component that has only recently begun to be evaluated to increase target behavior is synchronous reinforcement. Synchronous reinforcement is a schedule of covariation, a schedule of reinforcement in which changes in a target response produce corresponding changes in a reinforcer (Williams & Johnston, 1992). In a synchronous schedule, the onset and offset of reinforcement corresponds exactly to the onset and offset of the target response temporally. In synchronous schedules, the covariation is all-or-nothing, meaning that if the target response is occurring, reinforcement is delivered simultaneously, whereas if the target behavior is not occurring, reinforcement is not delivered. For example, when riding a bike, the rider must keep both feet on the peddles or on the ground (target response) in order to simultaneously keep the bike upright (reinforcement). If the rider takes both feet off the peddles while riding without placing at least one foot on the ground, the bike will not simultaneously remain upright. A synchronous reinforcement contingency would have the practical benefit of simplicity of implementation during treatment for increasing passive MDC because many reinforcers conducive to being

delivered synchronously are intangible and can be delivered for extended durations of time (e.g., a shuffled playlist of music, YouTube® videos). A synchronous reinforcement contingency could also be implemented discretely (e.g., synchronous music delivered via headphones) if the intervention is implemented in a more public space (e.g., a doctor's office, a hospital laboratory).

One of the earliest uses of a synchronous schedule of reinforcement in the applied literature was by Ramey et al. (1972) to increase vocal responding of two failure-to-thrive infants at risk of atypical development and two typically developing infants. All sessions took place in an enclosed crib-like apparatus with an infant seat, and experimenters were able to observe sessions through a small hole through the door of the crib. The apparatus was fitted with a voice activated relay microphone that was connected to a visual stimulator that produced a brightly colored, geometric figure on a white background visible to the infant in the apparatus when vocalizations reached a preset volume threshold. Baseline vocal responding was measured during a single session for each participant except for one participant whose vocalizations were near zero, so additional observation time was necessary to ascertain whether he emitted any vocal responses and could proceed in the study. During initial baseline sessions, there were no programmed consequences for vocalizations (i.e., relay microphone and the visual simulator were turned off). Following baseline, one 10 min session per day was conducted with each participant for the remainder of their hospitalization. During the conditioning phases, contingent on the infant emitting vocalizations at or above the criterion threshold, the visual stimulator produced the multi-colored geometric shape image. If the experimenter determined that the infant's vocalizations were cry

responses, the visual stimulus was turned off manually. These conditions were repeated in a reversal design. Increases in vocalizations following the intervention were observed for all four infants both in terms of frequency and duration of utterances. Anecdotally, an increase in the complexity of the infants' vocalizations was also observed (i.e., progress from single syllable utterances to multi-syllabic utterances).

A more recent demonstration of the use of synchronous reinforcement to increase a target behavior was conducted by Villegas et al. (2020) with eight typically developing preschoolers. The experimenters compared the effects of a synchronous reinforcement contingency versus an accumulated reinforcement contingency on academic task engagement. They compared the two schedules using a multielement design with an initial baseline phase, which was followed by an assessment of participant preference for the two schedules using a concurrent chains procedure. Prior to sessions across all conditions, 10 s of pre-session exposure to the session contingencies was provided. During the baseline phase, the experimenter provided an initial prompt to engage in tracing (the academic task) for 10 s but no consequences were programmed for engagement in the target task or engaging in other behaviors. In synchronous reinforcement sessions, preferred music and attention in the form of conversation was provided synchronously when the participant was actively engaging in tracing. If the participant discontinued tracing for 2 s, the music and attention were also discontinued until the participant resumed engaging in the target task. In the accumulated reinforcement condition, preferred music and attention in the form of conversation were provided following the 5 min session for the duration of time the participant engaged in the target task during session. The synchronous reinforcement

contingency resulted in greater increases in target task engagement for seven out of eight participants and these participants also displayed a preference for the synchronous condition. Differences between the synchronous and accumulated contingencies were not observed for one participant, and this participant also did not display a definitive preference for either condition (Villegas et al., 2020).

The consistency of the results across participants in Villegas et al.'s (2020) evaluation suggests that the implementation of a synchronous schedule of reinforcement could be useful in increasing other target behavior such as MDC. One recent evaluation of the synchronous schedule of reinforcement to increase MDC was conducted by McHugh et al. (2022) with five adults with developmental disabilities and nine group home staff. They assessed the synchronous schedule via a non-concurrent multiple baseline design with an embedded reversal design followed by generalization probes conducted in community settings and assessment of the social validity of the intervention to the group home staff. During the baseline phase, staff instructed the clients to put on their face masks and assisted with placing the mask if needed. Prompts were delivered to put the face mask back on contingent on device removal during the 5 min sessions within 5 s of the first removal and every 30 s after the initial removal. Prior to the start of synchronous reinforcement sessions, the staff instructed the client to select music or video to access during the session which immediately followed. Then, the 5 min session began with a brief instruction to put the mask on and a rule statement of the contingencies in place (i.e., access to audio-visual for compliance, access removed contingent on noncompliance). Synchronous reinforcement session duration increased incrementally to 10, 15, then 30 min when an increasing trend in face mask

compliance duration near the total session duration was observed. Once a terminal session duration of 30 min was reached, staff conducted generalization probes in community settings with four of the five participating clients with baseline contingencies in place. Synchronous reinforcement resulted in increases in face mask compliance for all participants and responding was maintained in the absence of treatment contingencies for three out the four clients. All staff endorsed that the intervention was acceptable and the procedures were easy to implement via a questionnaire completed at the end of the study (McHugh et al., 2022).

In addition to establishing initial brief durations of compliance, considerations for systematically extending compliance across longer durations beyond a typical research session duration of 5 to 10 min are critical when designing and implementing interventions. Although for some participants longer durations of compliance may emerge without direct intervention, some participants may require specific programming to shape longer durations of compliance. One method to systematically extend the duration of compliance is shaping with a percentile schedule of reinforcement (Galbicka, 1994). Shaping refers to the process of differentially reinforcing successive approximations of a terminal, target response. Whether with a percentile schedule of reinforcement or otherwise, shaping involves following several rules. First, the initial reinforcement criterion at the outset of the shaping process must be set at a value that has been exhibited by the individual within the individual's current range of response variation. Second, the terminal response must be clearly defined. Third, the reinforcement criterion must increase incrementally in response to recent changes in responding, not an arbitrary, static value of responding (Galbicka, 1994). These

components of shaping are formalized mathematically in the percentile schedule equation, $k = (m + 1)(1 – w)$, originally developed by Platt and colleagues (1973). In the equation, $m$ represents a fixed number of recent values of observations, and $w$ represents the probability of the density of reinforcement. The $k$ value resulting from the equation is the ranking of the response value the next response must exceed to contact reinforcement. Once the parameters in the equation are determined, recent observations must be ranked and based on the ranking, the current reinforcement criterion for a given observation period can be set and used in the treatment context. For example, if an experimenter chose to include the last 10 previous observations of a client's toothbrushing duration when determining a duration criterion the participant must meet or exceed to earn the reinforcer for the next toothbrushing session, $m = 10$. If the experimenter determined that the probability of observing a response that meets the criterion and contacts reinforcement should be 50%, $w = 0.5$. Given the percentile schedule formula, $k = (m + 1)(1 – w)$, in this example $k = (10 + 1)(1 – 0.5)$, resulting in $k = 5.5$, which would round down to the ranking of 5 (or up to 6). The ranking must be a whole number but rounding up or down is arbitrary. This means in the next toothbrushing session, the participant would have to brush their teeth at least as long as the fifth ranked observation out of the 10 prior observations being taken into account to access reinforcement. This formal application of the rules of shaping ensures that the current reinforcement criterion for an individual is sensitive to their most recent responding and that reinforcement during the shaping process is consistent across implementers (Athens et al., 2007; Galbicka, 1994).

One of the only demonstrations of the use of percentile schedules in the applied literature was conducted by Athens et al. (2007) in which they evaluated the effect of manipulating the *m* parameter, the number of observations considered when determining the criterion for reinforcement, on the duration of task engagement using a reversal design with four participants. In the initial baseline phase, an initial instruction explaining that the participant could work if they wanted to and that they could trade in the tokens they earned during the session at the conclusion of session, was delivered. Tokens were earned irrespective of responding on an FT 2.5 min schedule in baseline. Prompts to continue working were also delivered on an FT 15 s schedule. No other contingencies were programmed during baseline. Tokens were exchangeable for small, preferred edible items at the end of baseline sessions. All participants were exposed to a percentile schedule of reinforcement and three of the four participants also experienced parametric assessments of the *m* value of the percentile schedule. The predetermined *m* values in the parametric assessment were 5, 10, and 20 (e.g., in the *m* = 5 condition, 5 previous observations were taken into account to determine the *k* ranked value that would serve as the reinforcement criterion in the subsequent session). For the single participant who was not exposed to the parametric assessment, *m* = 20 for all percentile schedule sessions. Results across participants indicated that the percentile schedule was effective when a relatively large number of previous observations (a large *m* value) was used to determine the reinforcement criterion. However, this finding was in contrast to a previous group design study that parametrically assessed the *m* value and applied percentile schedules of reinforcement to decrease cigarette smoking (Lamb et al., 2005). These studies differed

methodologically in that in the former, multiple observations were conducted throughout the day, but in the latter, only one observation was conducted per day. Athens et al. (2007) tentatively recommended using larger *m* values when more observations are to be conducted each day but that smaller *m* values may still yield clinically significant behavior change if fewer observations are to be conducted each day.

Despite Galbicka's exhortation to applied researchers and practitioners to utilize percentile schedules as well as Athens et al.'s (2007) recommendations for future research, there have been only two other demonstrations of the use of a percentile schedule to shape target responses in the applied behavior analytic literature to date (Clark et al., 2016; Hall et al., 2009) and no application of the percentile schedule for target behaviors of durations beyond 10 min. The fact that the efficacy of many medical devices is dependent on compliance for more extended durations than 10 min (e.g., face masks, eyeglasses, hearing aids) coupled with the need for deliberate programming for extending the duration of compliance for some individuals, indicates a gap in both the shaping and MDC literature.

The purpose of the current studies is to systematically replicate the NCR intervention previously demonstrated as effective for increasing MDC by DeLeon et al. (2008) and Richling et al. (2011), examine the additive effect of a synchronous schedule of reinforcement on MDC, assess participant preference for the addition of synchronous reinforcement to the intervention, and demonstrate the use of a percentile schedule to shape increasing durations of MDC.

# General Method

Two clients at an outpatient applied behavior analysis (ABA) clinic participated in the two experiments: Ben and Hosea. Ben was 18 years old, male, White, and was diagnosed with an Autism Spectrum Disorder (ASD). Ben primarily communicated with facial expressions, joint attention (i.e., shifting his gaze from objects to other people and shifting his gaze back to objects) and occasional nonspecific vocalizations. Hosea was 7 years old, male, White, and was diagnosed with ASD and Attention-Deficit Hyperactivity Disorder (ADHD), combined type. Like Ben, Hosea also primarily communicated with facial expressions, joint attention, and occasional nonspecific vocalizations.

All experimental sessions took place in a multi-purpose room (i.e., 3 m x 4.5 m room with a couch, a bookshelf with books and DVDs displayed, a television and DVD player on a media cabinet, and a whiteboard) at the ABA clinic or in the participants' group therapy room (i.e., a 6 mx 9 m room with several child-sized tables and chairs, bookshelves with activities and toys, cubbies with clients' belongings, an individual trampoline, and an open area for play).

## Experiment 1 Method

### Materials

Necessary materials for all sessions in Experiment 1 included KN95 face masks, preferred items and activities identified via preference assessments, a Bluetooth speaker to play preferred music identified via preference assessments, a television connected to a DVD player and preferred DVDs for Ben only, and Skittles (a highly

preferred edible item) for Ben only. Data collectors recorded direct observation data on Surface Pro 3® tablets with the Lily Data Collector application.

**Response Measurement and Interobserver Agreement**

Dependent variables were the percentage of session in compliance with wearing the medical device and selection responses in stimulus preference assessments. Compliance was defined for both participants as wearing an KN95 face mask with the ear loops around each ear with the mask covering the participant's nose and mouth without the participant manually removing the mask from their face. That is, if the mask slipped off the participant's nose, this was not considered out of compliance and the therapist prompted or assisted the participant in re-placing their mask in the proper position.

During the preference assessments, observers recorded a selection response when a participant engaging with a stimulus (presented in an array or presented alone). Engaging with a stimulus was defined as interacting with the stimulus by moving towards the stimulus (e.g., moving toward the Bluetooth speaker projecting a song, moving their body to the rhythm of the music), physically interacting with a tangible item (e.g., completing a puzzle, engaging in functional or non-functional play behavior with a toy), or emitting vocalizations or facial expressions indicative of enjoyment of the stimulus (e.g., smiling when a song played versus a neutral expression, humming along to the tune of a song).

Interobserver agreement (IOA) data for duration of compliance was collected using the proportional agreement method. All sessions were divided into 10-s intervals. The smaller duration or number of responses recorded by the data collectors within

each interval was divided by the larger number, those proportions added, and the sum of all proportions divided by the total number of intervals. The resulting proportion was converted to a percentage. If both data collectors recorded a duration of 0 s for a given variable or 0 responses in an interval, that was considered an exact agreement, and the proportion for that interval was 1. IOA for selection responses was also calculated using the proportional agreement method. IOA was assessed across all phases of the experiment for both participants. For Ben, mean IOA for duration of MDC was 94.49% (range, 83.87%-100%) across 50.00% of sessions. For Hosea, mean IOA for duration of MDC was 94.19% (range, 83.87%-100%) across 40.00% of sessions. IOA for selection responses for all participants during preference assessments was 100%.

**Pre-assessments**

The experimenter conducted pre-assessments to determine a ranking of participant preference for music and activities that were then used in experimental conditions. First, the experimenter attempted to conduct modified paired stimulus preference assessments to determine each participant's preference for 10 songs selected based on parent report of participants' preferences and popular children's songs at the time of the assessment (Fisher et al., 1992; Horrocks & Higbee, 2009). However, barriers to participation in the modified paired stimulus preference assessment emerged for both Ben (positional bias) and Hosea (consistent movement around the room prevented attending to stimuli in the array), necessitating the use of single stimulus engagement preference assessments to assess their preference for auditory stimuli (Hagopian et al., 2001). In the single stimulus engagement preference assessment of auditory stimuli, songs were presented for 30 s each, and observers

recorded the duration of engagement. This procedure was repeated twice with each stimulus, and the duration of engagement across the two sessions was averaged. The average durations of engagement for the stimuli were ranked from most engagement to least. The top five ranked stimuli were used in the treatment conditions as reinforcers.

Following the auditory preference assessment, a response-restriction assessment (Hanley et al., 2003) was conducted with Ben and another single stimulus engagement preference assessment was conducted with Hosea to determine a ranking of preferred activities and items for each participant (Hagopian et al., 2001). Prior to the first trial of the response restriction assessment with Ben, the experimenter arranged the activities in an array and prompted Ben to engage with each item or activity for 15 s. Before each trial began, the experimenter provided a brief instruction letting Ben know he could engage with each activity as much or as little as he chose during the trial, which would last for 2 min. If Ben engaged with an item or activity for 60% of the trial or more across two trials consecutively, the item was removed from the array for subsequent sessions. If Ben had allocated 60% or more of the trial to a group of items roughly evenly across items in the group, those items would have been considered ranked equally and removed from subsequent trials. In all trials, Ben engaged with only one item for 60% or more of the trial, so only one item was removed from the array at a time for each session. Trials continued until Ben engaged with an item in the array for 60% or more of session until only a single item remained. For the single stimulus engagement preference assessment for preferred activities with Hosea, the procedure was identical to the preparation previously described with auditory stimuli except that each physical item was presented alone.

## Procedure

The experimenter evaluated the effects of a baseline condition (escape contingent on device removal only) and two treatment conditions, escape plus noncontingent reinforcement (NCR), and escape plus NCR plus synchronous reinforcement, on MDC with an initial baseline phase followed by a multielement comparison of treatment conditions and baseline. The experimental condition conducted in the first session of each day in the multielement phase alternated across days to control for potential variation between the first session of the day and latter sessions in a session block in device habituation, reinforcer satiation, and device fatigue (i.e., responses to aversive stimuli produced after use of a medical device for a prolonged period). The experimenter conducted one to three sessions per day in one session block 1 to 4 days per week. Two sessions of each treatment condition were conducted for each baseline session in the multielement phase of the evaluation (i.e., a 4:1 ratio of experimental to control sessions).

Each session began when the experimenter placed the KN95 face mask properly on the participant. Once the device was on, the experimenter delivered a brief, general instruction, “Today you are going to practice wearing your mask. Please try your best.” Each session was approximately 5 min in duration.

### *Baseline (escape only)*

The two lowest ranked items or activities identified during the response restriction assessment with Ben and the single stimulus engagement preference assessment with Hosea were available throughout all baseline sessions. During baseline sessions, no programmed consequences for MDC were delivered. Contingent on 15 s of

noncompliance (escape from the medical device), the experimenter re-presented the medical device to the participant by placing the mask back on the participant.

### *Treatment conditions*

During all treatment conditions, 15 s of escape from the medical device was allowed contingent on medical device removal (consistent with baseline). Following 15 s of escape, the experimenter re-presented the medical device as in baseline. The experimenter delivered attention at least every 30 s in all treatment conditions in the forms of responses to bids for attention, general comments, and praise. For Ben, at session 15 preferred audio-visual stimuli (movies and videos) as reported by his clinical behavior analyst was substituted for preferred music after several sessions of no observed sustained increase in MDC in the treatment conditions. Following no observed sustained increase with this substitution, preferred edible items (Skittles) were delivered approximately every 5 s contingent on compliance, and an opportunity to consume the edible items was provided during escape periods for Ben.

**Escape plus NCR with tangibles and music.** In addition to escape contingent on medical device removal, NCR sessions included noncontingent access to the three top ranked items identified in the response restriction assessment for Ben and the single stimulus engagement preference assessment for Hosea. Noncontingent access to top preferred music identified in the auditory preference assessment was provided continuously throughout the session irrespective of the frequency or duration of device removal.

**Escape plus NCR with tangibles plus synchronous music.** Synchronous sessions were identical to NCR sessions except that access to preferred music was

provided synchronously contingent on MDC and discontinued during escape periods. The onset-offset criteria for access to music was 3 s (i.e., after 3 s of MDC, music began; after 3 s of noncompliance, music was paused until MDC resumes for 3 s).

**Treatment Integrity**

Experimenters evaluated treatment integrity during 50% of sessions for Ben and 40% of sessions for Hosea using a 6-step procedural checklist: delivering initial session instruction, displaying the condition correlated stimuli, allowing 15 s of escape contingent on device removal, re-presenting the device following the escape period, including condition specific stimuli in the session context with condition specific contingencies (e.g., bottom ranked preferred items only, highly ranked preferred items and continuous access to preferred music, highly ranked preferred items and synchronous, contingent access to preferred music), and ending session after 5 min. Treatment integrity was calculated by dividing the number of steps performed by the total number of steps and converting the resulting proportion to a percentage. Treatment integrity for both participants across conditions was 100%. IOA for treatment integrity was conducted in 27.27% of sessions for Ben and 25% of sessions for Hosea in which treatment integrity was conducted using exact item-by-item IOA. Observers' responses to each item on the checklist were compared, the number of exact agreements counted, and the number of exact agreements divided by the total number of items to yield a proportion which was then converted to a percentage. Treatment integrity IOA was 100% for both participants across conditions.

## Experiment 1 Results and Discussion

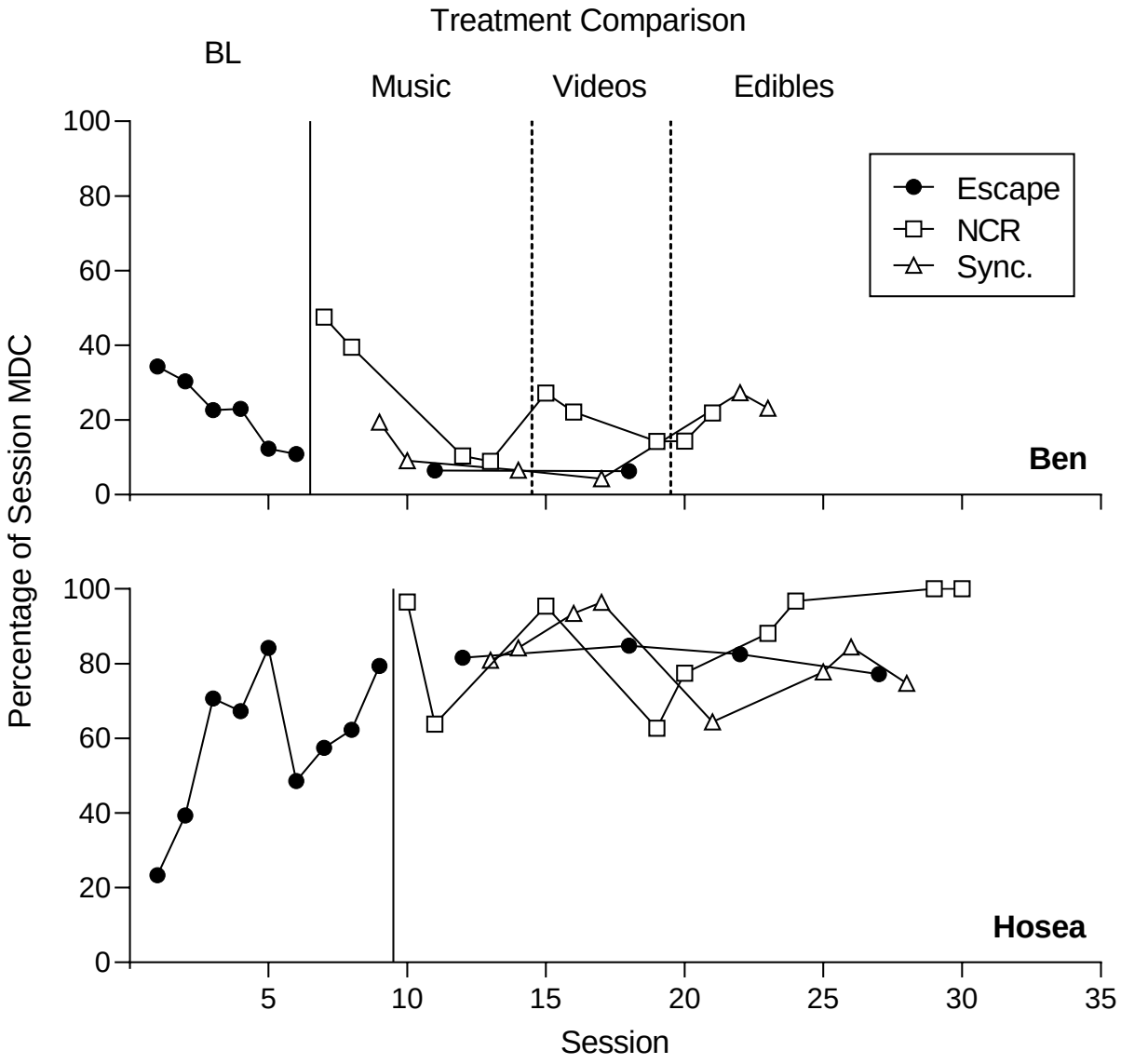


Figure 1. Percentage of Session Engaging in Medical Device Compliance (MDC) for Ben and Hosea.

*Note.* BL= Baseline, NCR = Noncontingent reinforcement, Sync. = Synchronous reinforcement
[a] The phase labels on the top panel denote modifications to preferred items available for Ben

The top panel of Figure 1 displays the percentage of session duration spent in MDC across experimental phases for Ben. Ben's percentage of session spent in MDC was slightly higher in the treatment conditions in which highly preferred items were available (NCR and synchronous reinforcement conditions) than in the initial baseline

phase. Ben's responding remained near zero percent MDC during sessions with baseline contingencies in the multielement treatment comparison (Escape sessions). Several modifications were made for Ben to preferred items available in the treatment conditions during MDC and during escape periods as indicated by the dotted phase change lines and phase labels (Music, Videos, Edibles). Some differentiation in the percentage of session duration engaged in MDC emerged initially for Ben. However, the increase in MDC in treatment conditions (NCR and Sync.) was inconsistent and the trend in both conditions plateaued despite modifications made to the treatment procedures.

The bottom panel of Figure 1 displays the percentage of session duration spent in MDC across experimental phases for Hosea. In the initial baseline phase and in the control condition sessions in the multielement treatment comparison (Escape), Hosea's responding increased then plateaued below 100% MDC. In the reinforcement treatment conditions, differentiation in the percentage of session spent in MDC was observed, with greater percentage of session in MDC and ultimately mastery of 100% session spent in MDC observed in the NCR condition.

Compared to the baseline condition in which reinforcement was not available for MDC in Experiment 1, Hosea engaged in MDC for a differentially greater duration during sessions in treatment conditions. Clear differentiation emerged between the NCR and the synchronous conditions for Hosea, as he spent 100% of the session in MDC across only two consecutive sessions in the NCR condition. In contrast, Ben's percentage of session spent in MDC was only slightly higher in the treatment conditions versus baseline. The increase in MDC in treatment conditions for Ben was inconsistent,

and Ben did not meet the mastery criterion despite multiple modifications made to the treatment procedures.

The results of Experiment 1 are consistent with the current literature regarding NCR as a standalone intervention for increasing MDC in that NCR alone does not always increase MDC (DeLeon et al., 2008; Richling et al., 2011). Similar to the results of NCR alone in DeLeon et al.'s preparation (2008), NCR was not universally effective on its own to increase MDC to target levels. In contrast, the participants in Richling et al.'s (2011) both responded to NCR as a standalone intervention. One potential reason that some individuals do not display a substantial increase in MDC under NCR is that the preferred items provided noncontingently did not provide greater reinforcement according to some dimension (e.g., delay, magnitude or quality) than the negative reinforcement accessed via device removal. Additionally, although preference assessments can serve as an indication of what items may function as reinforcers, they may be less successful at identifying items that can compete with the negative reinforcement contingency of device removal. Given the differential efficacy of NCR as a standalone intervention in the current study and the extant literature, practitioners will likely need to add additional treatment components for some patients. This can be accomplished by the addition of aversive contingencies (e.g., escape extinction, response cost) or through different arrangements of positive reinforcement contingencies. Aversive contingencies may not be safe, realistic, or acceptable to implementers or patients receiving intervention and have various undesirable side effects that may not be easily managed in many treatment contexts (Lerman et al., 1999; Lerman & Vorndran, 2002). For example, an extinction burst involving more

intense topographies of device removal (e.g., throwing a medical device, aggressing toward the individual implementing escape extinction) could pose both a risk to damaging the device itself or harm individuals involved in treatment. Therefore, with respect to increasing MDC, in clinical practice different arrangements of positive reinforcement contingencies should be explored prior to the addition of aversive contingencies to treatment packages as in the current study. Future research should explore the most efficient arrangements of positive reinforcement contingencies in addition to or instead of NCR to balance patients' right to effective treatment with avoiding the side effects of aversive contingencies.

The results of Experiment 1 were not entirely consistent with the current, albeit limited, literature regarding the synchronous reinforcement schedule to increase socially significant target behavior. Unlike in Villegas et al.'s (2020) evaluation of the synchronous schedule to increase task engagement with preschoolers and McHugh et al.'s (2022) evaluation of the synchronous schedule to increase face mask compliance with adults with developmental disabilities living in a group residential setting, neither of the participants in the current experiment displayed consistent, sustained increases in MDC with the synchronous schedule of reinforcement. One potential reason for the consistently different results in the current experiment compared to the current literature is that for the two participants in the current study, the positive reinforcing value of the stimuli delivered synchronously (i.e., music) may not have been great enough to overcome the negative reinforcement available contingent on device removal. In addition, removal of preferred stimuli may have functioned as a punisher for engagement with the medical device to the participants in the current experiment. That

is, the participants in the current study removed their face masks so many times during initial treatment sessions, removal of preferred stimuli occurred frequently, and the total duration of time spent with access to the reinforcer was limited, so their experience with the positive reinforcement aspect of the contingency was more limited than the removal aspect. Further, the participants in the current experiment were not able to participate in array-based preference assessments before each session which yield more valid, up-to-date predictions regarding the moment to moment reinforcing value of preferred stimuli (Hagopian et al., 2001). Consequently, the stimuli provided on a synchronous schedule in the current experiment may not have functioned as reinforcers as well as the stimuli in Villegas et al. and McHugh et al.'s preparations. Future research should demonstrate additional contexts in which the synchronous schedule of reinforcement effectively increases target behavior and under what conditions the covariation of reinforcer delivery is necessary to increase target behavior when noncontingent access alone is insufficient to increase target behavior.

Several limitations of the current experiment warrant discussion and may have impacted the efficacy of the reinforcement schedules evaluated. First, the use of single stimulus engagement preference assessments in the current study for both participants (except for Ben's activity preference assessment) was not ideal in that preference rankings are less stable when items are presented singly rather than in an array (Hagopian et al., 2001). Although presenting items singly was necessary given barriers to participation in array-based preference assessment that emerged for both participants, the use of single stimulus engagement preference assessments may have resulted in less reliable preference rankings and less potent reinforcers than would be

necessary to overcome the negative reinforcement available from device removal. In addition, another limitation of the current experimental preparation is that Ben's participation in Experiment 1 was discontinued before he met the mastery criteria in either condition. It is possible different outcomes could have been observed if the experiment had been conducted for more sessions or if additional treatment components had been paired with the reinforcement schedules. Although conducting additional sessions of the reinforcement schedules under evaluation in the experiment with more modifications than those attempted (e.g., introducing different preferred items hypothesized to have greater value than music such as movies and edibles) may have enhanced the strength of the evaluation, keeping Ben in Experiment 1 lacked clinical utility given time constraints of Ben's participation (i.e., Ben was moving to a new residential placement at a certain point in the school year and participation would have to be discontinued at that time).

## Experiment 2 Method

The two main purposes of Experiment 2 were to extend the duration of MDC for each participant and to parametrically evaluate the effects of the *m* value on participants' performance to guide practitioners in selecting appropriate *m* values. The secondary purpose of this experiment was to systematically replicate Athens et al.'s (2007) parametric evaluation of the *m* value with a novel target behavior, MDC.

### Materials

Necessary materials for all sessions in Experiment 2 included KN95 face masks, preferred stimuli (e.g., items and activities, music) identified at the outset of Experiment 1 for Ben only, Skittles for Ben only, and materials for a preferred therapy activity for

Hosea (e.g., slime, rice sensory bin, puzzles). Data collectors used Surface Pro 3® tablets to record direct observation data in the Lily Data Collector application.

**Response Measurement and Interobserver Agreement**

The primary dependent variable in Experiment 2 was the latency to medical device removal. IOA for latency to medical device removal using the proportional agreement method as described in Experiment 1 was assessed across all phases of the experiment for both participants. For Ben, mean IOA for latency to device removal was 97.67% (range, 83.87%-100%) across 31.82% of sessions. For Hosea, mean IOA for latency to medical device removal was 100% across 36.00% of sessions.

**Procedure**

The experimenter compared the effects of a baseline condition (escape contingent on device removal) to three percentile schedule conditions in which only the values of *m* varied (*m* = 5, 10, 20) in a parametric design, followed by a maintenance phase. The order of *m* values introduced were counterbalanced across participants. If the target duration was not maintained in the absence of additional contingencies in the maintenance phase, the percentile schedule that showed the greatest treatment effect for the given participant was reintroduced (Athens et al., 2007). The percentile schedule with the greatest treatment effect was reintroduced for Ben only. During all sessions, for Hosea, he engaged in a preferred therapeutic task (e.g., playing with a rice sensory bin, playing with slime, completing a puzzle, coloring). During all sessions for Ben, the context included access to top ranked items from the response restriction assessment of activities. Across all conditions, sessions were terminated upon device removal. In addition, attention was delivered at least every 30 s in all conditions in the forms of

responses to bids for attention, comments, and praise. The experimenter conducted 1 to 3 sessions per day in one session block 1 to 3 days per week.

### *Baseline*

In baseline, the session began with the experimenter placing the face mask properly on the participant's face. In baseline, no consequences were provided contingent on MDC. Sessions were terminated contingent on device removal.

### *Percentile schedule*

In the percentile schedule conditions, longer duration MDC was shaped using the percentile schedule equation. If the criterion was met or exceeded, the experimenter delivered brief access to preferred auditory stimuli identified via single stimulus engage preference assessments at the outset of Experiment 1. Access to the preferred auditory stimuli did not exceed 2 min and was terminated at a natural break in the song or at the conclusion of the song.

The *w* value was set at 0.5 across all percentile schedule phases because at this criterion, approximately half of the participant's responses contacted reinforcement. This *w* value is consistent with the available literature (Athens et al., 2007; Clark et al., 2016; Lamb et al., 2005). The *m* value is a fixed number of observations of the maximum duration of MDC across recent sessions. The *m* value parameters assessed were 5, 10, and 20, as in Athens et al. (2007). The order in which participants were exposed to each *m* value was counterbalanced across participants. The resulting *k* value is the ordinal rank of the duration of compliance that the response in the next session must meet or exceed to contact reinforcement. The *k* values corresponding to the *m* value parameters being assessed were 3, 5 (5.5. rounded down), and 10 (10.5 rounded down),

respectively. Rounding up or down to a whole number is permissible, but the experimenters chose to round down to ensure that participants would be slightly more likely to meet or exceed the response duration at *k* rank than with the higher ranked value yielded from rounding up.

The experimenters used paper and pencil data sheets to rank the observed values of the duration of device compliance in ascending order and determined the value at *k* rank, the reinforcement criterion. An example of the paper and pencil data sheet used during the experiment can be found in Appendix B. The latter *m* (5, 10, or 20) values observed in this experiment's baseline and the previous experiment were used to determine the initial reinforcement criterion for the first percentile schedule session. When a new response was recorded, the oldest response in the set of *m* was discarded, and the new set of *m* observed values informed the reinforcement criterion value for the next observation in phase. For example, if after three baseline sessions steady state responding was observed for a participant and the first *m* value assessed for the participant was 10, the experimenter ranked the maximum duration of compliance from those three sessions in addition to the seven most recent durations from Experiment 2. With an *m* value of 10, the value of *k* is 5.5, which is the whole number 5 rounded down or the fifth ranked observation. The fifth ranked duration out of the 10 would be the criterion duration of compliance in the first percentile schedule condition session of the first percentile schedule phase.

**Treatment Integrity**

Experimenters evaluated treatment integrity during 31.82% of sessions for Ben and 36% of sessions for Hosea using the following 3-step procedural checklist:

delivering initial session instruction, terminating session contingent on device removal, delivering condition specific consequences following session termination (no specified consequences in baseline; delivery of access to preferred music contingent on meeting the percentile schedule criterion in percentile schedule conditions). Treatment integrity and treatment integrity IOA were calculated using the same methods described in Experiment 1. Treatment integrity across conditions for both participants was 100%. IOA for treatment integrity was conducted in 28.57% of sessions in which treatment integrity was measured for Ben and 22.22% of sessions for Hosea and was 100% for both participants across conditions.

## Experiment 2 Results and Discussion

Figure 2 shows the latency to device removal for both participants across baseline and shaping phases with varying *m* values. The top panel of Figure 2 displays the latency to medical device removal for Ben in seconds. Ben's latency to medical device removal in baseline sessions and in treatment sessions in which the *m* value in the percentile schedule was 10 or 20 (i.e., more than five observations were used to determine the reinforcement criterion for the session) remained low and relatively stable. Ben's latency to medical device removal was markedly higher with an increasing trend when only the five most recent observations were used to determine the reinforcement criterion for each session (m = 5). In the absence of reinforcement delivered contingent on meeting the latency criterion in the maintenance phase, Ben's responding returned to baseline levels. Ben's responding increased with the resumption of reinforcement contingent on meeting the criterion when m = 5. Of note, Ben's latency

to device removal was approximately 1 min during sessions in the final phase with the resumption of reinforcement delivered contingent on meeting the criterion when m = 5.

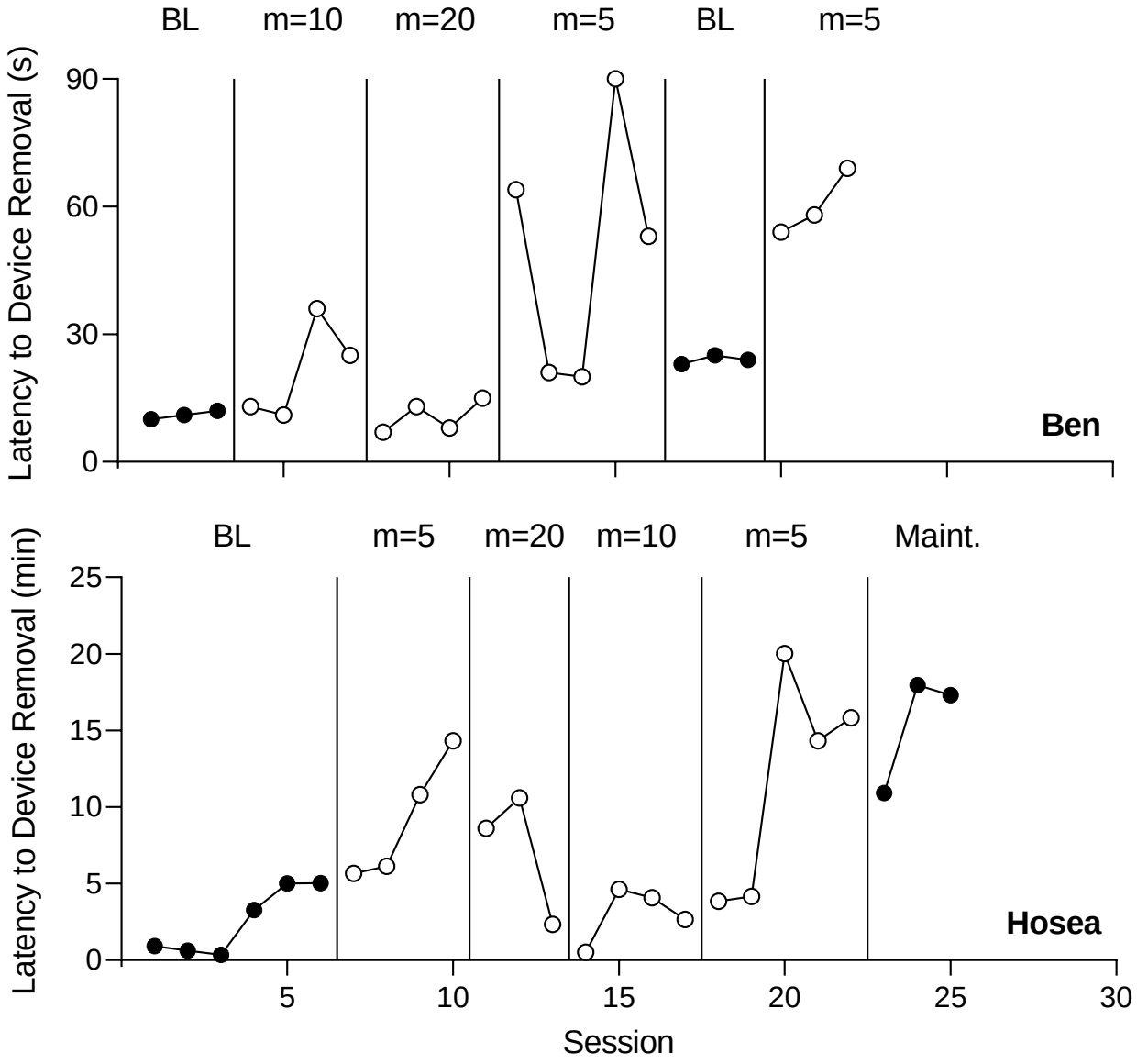


Figure 2. Latency to Device Removal for Ben (in seconds) and Hosea (in minutes).
*Note.* BL= Baseline, m = number of observations to determine criterion, Maint. = Maintenance

The bottom panel of Figure 2 displays the latency to medical device removal for Hosea in minutes. Like Ben, Hosea's latency to medical device removal in baseline sessions and in treatment sessions in which the *m* value in the percentile schedule was 10 or 20 (i.e., more than five observations were used to determine the reinforcement

criterion for the session) remained low and relatively stable. Hosea's latency to medical device removal was higher with an increasing trend when m = 5. Hosea's responding maintained in the absence of reinforcement delivered contingent on meeting the latency criterion in the maintenance phase. His maximum latency to device removal was approximately 17 min in the maintenance phase.

Compared to the baseline condition and other *m* value phases, Ben's latency to device removal was greatest with an increasing trend in percentile schedule phases when the *m* value was 5. Ben's responding did not maintain in the absence of reinforcement contingencies. Similarly, Hosea's latency to device removal was differentially greater during percentile schedule phases when the *m* value was 5. However, unlike Ben, Hosea's responding was maintained in the absence of reinforcement contingencies.

The results of the current experiment differed from the most recent demonstration of the percentile schedule applied to increasing a behavior with social significance. In Athens et al.'s (2007) evaluation of the percentile schedule to increase academic task engagement with children receiving special education services in elementary school, the target behavior increased most consistently under the percentile schedule of reinforcement when the *m* value was 20 (i.e., 20 recent observations were ranked to determine the reinforcement criterion or *k* ranked value). The differences between Athens et al.'s preparation and results and the results of the current experiment underscores the importance of the training context in selecting the *m* value to maximize the utility of the percentile schedule. In Athens et al.'s evaluation, sessions lasted a maximum of 5 min for 3 participants and 10 min for 1 participant. Two to three

sessions were conducted each day approximately 4 to 5 days per week, so the 20 most recent observations used to determine a value for the next session were roughly within the most recent week. In the current experiment, we were only able to conduct 1 to 2 sessions each day, approximately 3 days per week, so when the *m* value was 5, this represented approximately one week of direct observation data. Sessions for Hosea lasted a minimum of 5 min with a maximum of approximately 17 min. Therefore, in terms of recency, observations in both Athens et al.'s evaluation and the current experiment were roughly within the same timeframe relative to determining the next session criterion. That is, although the *m* values with the greatest duration of target behavior differed across evaluations, the results of both evaluations suggest it is clinically useful to use observations within the recent past (i.e., about a week) to inform the reinforcement criterion. Considering the session duration and target behavior duration as well as the number of opportunities to respond in a given timeframe appear to be key variables in determining how to optimize the effects of the percentile schedule of reinforcement. Future research should examine additional contexts and manipulate these variables to further clarify when and how the percentile schedule could be successfully applied in practice.

Limitations of the current experiment that may have impacted the efficacy and scope of the conclusions regarding the use of the percentile schedule warrant discussion. First, Ben's maximum duration of MDC with the KN95 face mask under the percentile schedule of reinforcement was just under 90 s. This duration of compliance is not clinically or socially significant for the target behavior of mask wearing, as most settings when wearing a mask is required or could decrease the risk of viral

transmission require MDC for longer durations. Therefore, between-subjects replication of the utility of the percentile schedule of reinforcement to increase target behavior to socially significant duration was not demonstrated in the current experiment. However, within-subjects replication of the effects of the differential effects of the *m* value of duration of compliance were consistent within and across participants. Although mask wearing is not clinically useful for durations of 1 to 2 min, many medical devices and medical procedures only need to be worn or tolerated (e.g., pulse oximeters, blood pressure cuffs, venipuncture) for a short duration. Therefore, it is possible that although Ben did not display socially significant durations of compliance with the KN95 face mask, tolerance of aversive properties of the face mask might generalize to other medical devices or procedures that only take 1 to 2 min.

## General Discussion

Both participants' compliance with wearing KN95 face masks increased under the percentile schedule of reinforcement with an *m* value of 5. Only Hosea's compliance increased substantially from baseline with the NCR schedule, and neither participant's compliance increased consistently under the synchronous schedule of reinforcement. Hosea's responding under the percentile schedule of reinforcement ultimately maintained in the absence of reinforcement contingencies.

The differences and similarities observed in Ben and Hosea's response to the treatment contingencies evaluated suggest that several behavioral mechanisms can influence the acquisition of tolerance of medical devices. The influence of these mechanisms on MDC has implications on teaching MDC in clinical practice and relates to potential areas of future research on MDC. One common mechanism across the experiments was the behavior analytic account of choice (McDowell, 1989). That is, positive reinforcement contingencies had to out-compete negative reinforcement contingencies for the acquisition of the target skill to occur in the absence of programmed aversive contingencies. Most medical devices and contexts in which medical devices are used (e.g., home, hospital laboratories, outpatient clinical settings) are not highly controlled like research settings and the use of aversive contingencies is not safe or acceptable especially with adolescents and adults (e.g., the use of physical restraint as escape extinction for venipuncture is culturally permitted and physically feasible due to children's size; whereas this approach is not feasible with older children or adults). Future research should examine MDC through the lens of matching theory to further evaluate treatment components and packages that are applicable clinically and

more broadly examine how matching theory can be applied to make positive reinforcement contingencies more effective prior to implementing aversive contingencies.

Another behavioral mechanism at work in the current study with clinical implications was habituation or sensitization to the aversive properties of the medical device. Although in Experiment 1 sessions, the value of the negative reinforcement available for device removal appeared to be greater than the value of the reinforcement available contingent on compliance and noncontingently for both participants, it appears that after a certain “dosage” of exposure, the value of the negative reinforcement was abolished by the reinforcement available for compliance for Hosea (Laraway et al., 2003). Hosea demonstrated evidence beyond just the abolition of the aversive properties of the face mask when in the final phase of Experiment 2, his responding maintained in the absence of any reinforcement contingencies (McSweeney, 1996). Although Ben did not demonstrate the maintenance of responding in the absence of reinforcement contingencies, it is possible that had additional experimental sessions been conducted, Ben would have received a sufficient “dosage” for habituation to the aversive properties of the device to occur. Future research should examine when and how individuals may be exposed enough to the aversive properties of medical devices and procedures to habituate to the aversive properties. In addition, future research should attempt to distinguish when sensitization and intervention procedures that produce sensitization are appropriate given the target medical device or procedure.

In summary, the current study showed NCR can be an effective standalone intervention to increase MDC, but it is not a universally effective standalone

intervention. The current study also demonstrates that the percentile schedule of reinforcement can be clinically useful for increasing the duration of MDC. Further research on the mechanism of action influencing the efficacy of NCR as a standalone intervention, additional positive reinforcement components that can enhance the effects of NCR, and additional contexts in which the percentile schedule can be a clinically useful method for shaping behavior is needed.

# Appendix A. IRB Approval

LSU | Office of Research & Economic Development

| | |
|---|---|
| **TO:** | Donaldson, Jeanne Marie<br>LSUAM \| Col of HSS \| Psychology |
| **FROM:** | Alex Cohen<br>Chair, Institutional Review Board |
| **DATE:** | 29-Oct-2020 |
| **RE:** | IRBAM-20-0218 |
| **TITLE:** | An Evaluation of Procedures to Increase Medical Device Compliance |
| **New Protocol/Modification/Continuation:** | Modification |
| **Review Type:** | Expedited Review |
| **Risk Factor:** | Minimal |
| **Review Date:** | 29-Oct-2020 |
| **Status:** | Approved |
| **Approval Date:** | 29-Oct-2020 |
| **Approval Expiration Date:** | 19-Sep-2021 |
| **Re-review frequency:** | (annual unless otherwise stated) |
| **Number of subjects approved:** | 20 |
| **By:** | Alex Cohen, Chairman |

**Continuing approval is CONDITIONAL on:**

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc.**

## Appendix B. Percentile Schedule Data Sheet

Client:

m = 5 most recent observations → 3rd ranked value is criterion

**Session _____**

| Values: | Ranked Values: | CRITERION: |
|---|---|---|
| _____ | _____ | |
| _____ | _____ | |
| _____ | _____ | |
| _____ | _____ | |
| _____ | _____ | |
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**Session _____**

| Values: | Ranked Values: | CRITERION: |
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| _____ | _____ | |
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**Session _____**

| Values: | Ranked Values: | CRITERION: |
|---|---|---|
| _____ | _____ | |
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| _____ | _____ | |
| _____ | _____ | |

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# Vita

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